

## APPENDIX A: SCIENCE PROCESS SKILLS

**Science Process Skills** refer to those skills associated with standards and benchmarks in inquiry and problem solving. HCPS III has embedded the science process skills into Standard 1: Scientific Investigation. As students complete the entire inquiry process at all grade levels they discover, invent, and investigate using the following skills: observing; questioning; inferring and predicting using background information; making and testing hypotheses; identifying and controlling variables in the experimental design; collecting, recording, organizing, and interpreting data; concluding and communicating results.

Process skills are necessary for inquiry and problem solving behaviors. Acquiring and using these skills enables students to conduct scientific investigations and solve problems with a minimal amount of guidance. When appropriately applied, the process skills will enhance the quality of science concept understanding. These process skills also facilitate student achievement and proficiency in the Standards. The nine process skills covered in this appendix are:

- 1) Observing
- 2) Questioning, Inferring and Predicting
- 3) Making, Selecting, and Testing Hypotheses
- 4) Identifying and Controlling Variables
- 5) Collecting, Recording, Organizing, and Interpreting Data
  - 5a. Graphing
  - 5b. Using Equipment and Apparatus
  - 5c. Classifying
  - 5d. Measuring
  - 5e. Model Building
- 6) Using Scientific Vocabulary
- 7) Communicating
- 8) Using Space-Time Relationships
- 9) Process Integration

Each process skill has a number of objectives, which should be mastered by the student. Benchmarks, consistent with the HCPS III Content Standards, are given for each process skill. The student would be expected to meet the benchmark at the level expected for a particular age. This “degree of mastery” of these benchmarks, and subsequent development of each process skill, depends not only on the abilities of the student, but also upon the abilities of our teachers. Teachers are responsible for providing adequate opportunities for the student to meet the benchmarks of each process skill.

Inherent in all skills are the attitudes and habits of mind (see Appendix D.) These should not be overlooked. While it is recognized that reading and writing skills are also important parts of science, these skills are not treated separately. They are integrated as part of the enabling objectives for each process skill.

The following sections elaborate on the nine process skills listed above at grades K-5, at the end of middle school or grade 8, and at the end of high school or grade 12.

## 1) OBSERVING

Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)

### **By the end of kindergarten, students should be able to:**

- Use senses to make observations about the world around them.
- Identify objects and their properties (color, shape, texture, size, sound, quantity, etc.) using their five senses.
- Identify likenesses and differences in a variety of objects.
- Observe and describe changes in the properties of objects.

### **By the end of grade 1, students should be able to:**

- Use appropriate language when describing an object or making an observation (e.g., Is the object larger in length, width and weight?)
- State objects in quantitative terms whenever possible.
- State objects in qualitative terms whenever possible.

### **By the end of grade 2, students should be able to:**

- Identify the difference between statements of observation and opinion.

### **By the end of grade 3, students should be able to:**

- Use the appropriate senses to collect data to answer a question.

### **By the end of grade 4, students should be able to:**

- Distinguish between an observation and an inference.

### **By the end of grade 5, students should be able to:**

- Use observations to collect data in a scientific investigation.

### **By the end of grade 8, students should be able to:**

- Describe objects qualitatively and quantitatively.
- Distinguish between relevant and irrelevant information in the description of an observation.
- Identify the unknown by comparing it to properties and/or characteristics of what is known.
- Use clear and accurate observations to explain science concepts.

**By the end of grade 12, students should be able to:**

- Use emerging technology to enhance the depth and precision of observations.
- Increase the accuracy and processing rate of observations in the collection of data.
- Select and use sense enhancers appropriate to the information desired and subject being observed.
- Describe how observations may be affected by human physiology, emotions, perspective or frame of reference.

**2) QUESTIONING, INFERRING AND PREDICTING**

Questioning occurs as scientists make observations, read about theories, or wonder about the natural world. Questions can focus, guide, and frame how one tries to answer them. Defining or thinking about the question must occur before an inference.

Inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations.

Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.

**By the end of kindergarten, students should be able to:**

- Ask questions when they observe the world around them.

**By the end of grade 1, students should be able to:**

- Collect data to answer their questions.

**By the end of grade 2, students should be able to:**

- Make a prediction based on observation.

**By the end of grade 3, students should be able to:**

- Pose relevant questions based on observations.
- Collect and analyze data to answer the question(s).

**By the end of grade 4, students should be able to:**

- Distinguish between an observation and an inference.

**By the end of grade 5, students should be able to:**

- Construct one or more inferences from observations.
- Identify those observations which support an inference.

**By the end of grade 8, students should be able to:**

- Recognize when inferences need to be revised based on additional and more recent observations.

- Formulate a prediction based on a given set of observations.
- Conduct a test for predictions that have been made.
- Interpolate and extrapolate information from data.

**By the end of grade 12, students should be able to:**

- Construct or identify a test for a given inference.
- Categorize statements as logical inferences, facts, or opinions
- Make an if-then statement of two inferences between two related events.
- Determine and conduct additional observations and/or data collection, required to test an inference.
- Show the relationship between/distinguish between direct evidence and indirect evidence leading to an inference of an event or interaction.

### **3) MAKING, SELECTING, AND TESTING HYPOTHESES**

Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.

**By the end of kindergarten, students should be able to:**

- Identify or make a guess about the cause of an event.

**By the end of grade 1, students should be able to:**

- Make guesses and give reasons or data to support their guess.

**By the end of grade 2, students should be able to:**

- Conduct a simple investigation to test a prediction.

**By the end of grade 3, students should be able to:**

- Develop a hypothesis that relates to an observation.

**By the end of grade 4, students should be able to:**

- Distinguish between statements that are testable hypotheses and those that are not.

**By the end of grade 5, students should be able to:**

- Construct a hypothesis from a set of observations and inferences.
- Devise and conduct a test or tests for the formulated hypothesis.
- Choose an appropriate type of apparatus to be used to test a given hypothesis.

**By the end of grade 8, students should be able to:**

- Identify the degree of precision of measurement necessary for testing a simple hypothesis.
- Suggest or identify a test, which would support one hypothesis and weaken a competing hypothesis.
- Check that a hypothesis matches the existing information.

**By the end of grade 12, students should be able to:**

- Distinguish between a statement of opinion or belief and a hypothesis.
- Construct several experimental designs to test a given hypothesis and select the most appropriate procedure.
- Identify and analyze an “inappropriate” procedure for testing a hypothesis.
- Describe or identify a test for a revised hypothesis knowing the original incorrect hypothesis and data.

**4) IDENTIFYING AND CONTROLLING VARIABLES**

Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them.

The school Science Education Program should provide students with many investigative/ experimental experiences in order to help develop skills in identifying and controlling variables.

**By the end of kindergarten, students should be able to:**

- Make observations about variables that affect a result (e.g. sun = hot)

**By the end of grade 1, students should be able to:**

- Identify things or events that can change an outcome.

**By the end of grade 2, students should be able to:**

- Replicate a simple investigation by changing one part of the procedure (variable) at a time to get a different outcome.

**By the end of grade 3, students should be able to:**

- Collect and analyze data to answer a question
- Identify variables that could affect an outcome.

**By the end of grade 4, students should be able to:**

- Identify variables in an experimental procedure.
- Identify the variables that must stay the same if the experiment is repeated.

**By the end of grade 5, students should be able to:**

- Name variables that have affected or may affect the outcome of an investigation.
- Identify and name which variable should be controlled and manipulated in an investigation.

**By the end of grade 8, students should be able to:**

- Identify and name the manipulated and responding (independent and dependent) variables in an investigation.

**By the end of grade 12, students should be able to:**

- Construct a test for a hypothesis, inference or problem in which variables are identified.
- State the relationship between the responding (dependent) variable and the manipulated (independent) variable in an investigation.

**5) COLLECTING, RECORDING, ORGANIZING, AND INTERPRETING DATA**

Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table.

The school Science Education Program should provide the necessary experiences for students to develop skills in handling and interpreting data.

**By the end of kindergarten, students should be able to:**

- Collect data using the 5 senses.

**By the end of grade 1, students should be able to:**

- Collect, record, and organize data using simple tools, equipment, techniques.
- Explain results using simple data organizers.

**By the end of grade 2, students should be able to:**

- Communicate results of observations and simple investigations.

**By the end of grade 3, students should be able to:**

- Make graphic organizers to analyze systems and/or the results of investigations.
- Identify data to be collected to answer questions about the investigation.

**By the end of grade 4, students should be able to:**

- Identify data to be collected in an experimental procedure and communicate it in written or verbal form.
- Analyze data from a table or chart to make inferences or draw conclusions.

**By the end of grade 5, students should be able to:**

- Sequence observed changes in materials and systems both verbally and in writing.
- Organize collected data in tables, graphs, histograms, and/or matrices, to display an/or infer trends.
- Research and use accurate and technical information.
- Use data collected to formulate and defend conclusions.

**By the end of grade 8, students should be able to:**

- Make a written report of an investigation, including: Background Information, Problem, Hypothesis, Materials and Methods, Results, Analysis, and Conclusion.
- Identify and use the appropriate tools, equipment, and techniques to collect, display and analyze data.
- Represent and communicate data in multiple formats (verbal, written).

**By the end of grade 12, students should be able to:**

- Reorganize graphical representation of data to improve analysis.
- Extrapolate and interpolate to arrive at information not specifically presented in data.
- Identify significant pieces of data and determine connection between hypothesis and conclusion.
- Form, defend, and support logical conclusions based only on the data collected.
- Identify relationships between two variables in a given table.

**5a) GRAPHING**

Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph.

The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill.

**By the end of kindergarten, students should be able to:**

- Sort living and non-living things according to stated attributes.

**By the end of grade 1, students should be able to:**

- Construct and interpret simple graphs.

**By the end of grade 2, students should be able to:**

- Construct and accurately label data organizers to show data collected in a simple investigation.

**By the end of grade 3, students should be able to:**

- Identify different graphs and use them to organize data.
- Interpret and answer questions about data represented in graphs.

**By the end of grade 4, students should be able to:**

- Describe relationships of components illustrated in various graphs.

**By the end of grade 5, students should be able to:**

- Select appropriate graph(s) to depict the data collected.
- Construct, label, and interpret simple line graphs, bar graphs and circle graphs.

**By the end of grade 8 all expectations for graphing should be met:**

- Plot a set of points on a graph for a given set of data.

- Construct a line graph, including the construction and labeling of axes, marking off units, plotting points and drawing the line (or curve of best fit) for the graph.
- Locate a specific piece of information on a line graph and/or bar graph.
- Make inferences and logical conclusions for a given graph.
- Make a prediction from a given line graph which shows a linear relationship between two variables.

## **5b) USING EQUIPMENT AND APPARATUS**

The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use.

The school Science Education Program should provide students with many hands-on experiences in the use of science equipment and apparatus.

### **By the end of kindergarten, students should be able to:**

- Maintain a safe and healthy classroom environment at all times.

### **By the end of grade 1, students should be able to:**

- Properly retrieve, store, and maintain science equipment and supplies.

### **By the end of grade 2, students should be able to:**

- Recognize the names and functions of various instruments used in class.

### **By the end of grade 3, students should be able to:**

- Follow conventional procedures for effective use of equipment and apparatus.

### **By the end of grade 4, students should be able to:**

- Use appropriate instruments for making a particular measurement or doing a particular experiment.

### **By the end of grade 5, students should be able to:**

- Adapt or modify standard science procedures or equipment as needed, keeping safety in mind at all times.

### **By the end of grade 8, students should be able to:**

- Recognize the appropriateness, limitations, and safety concerns of certain laboratory equipment.
- Identify the names and function of various instruments and equipment used in the classroom.

### **By the end of grade 12, students should be able to:**

- Describe the names and functions of various instruments and equipment used in the classroom.
- Identify reasons for extensive use of precision tools in scientific research.



- Locate and safely use equipment needed for adequate inquiry or problem solving.
- Identify specialized measurement tools, laboratory hardware and software, sense extensors, electronic devices, and other technology used by various scientific disciplines.

### 5c) CLASSIFYING

The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into group or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out.

The Science Education Program should determine to what extent classification skills can be carried out. The school Science Education Program should promote the classification skills by providing as many developmental experiences as necessary.

**By the end of kindergarten, students should be able to:**

- Classify or sort objects or events by their properties.
- Use given or student-generated criteria to sort objects.

**By the end of grade 1, students should be able to:**

- Classify the same group of objects in several different ways.
- Use student-generated criteria to sort objects.

**By the end of grade 2, students should be able to:**

- Organize and analyze the classification of objects (living and non-living) in a matrix.

**By the end of grade 3, students should be able to:**

- Decide ways in which a group of objects are similar or different, and then identify another group of objects that are similar or different in the same way.

**By the end of grade 4, students should be able to:**

- Create and analyze the classification of objects (living and non-living) in a matrix.

**By the end of grade 5, students should be able to:**

- Classify one or more given subsystems within a corresponding system (i.e., circulatory, digestive, and respiratory systems are subsystems of the human body).

**By the end of grade 8, students should be able to:**

- Divide objects into groups according to a hierarchical system by listing and identifying how many objects would be in a total set, given the properties of the objects in subsets and how many objects would be in each subset.

- Identify the property which was used to divide a set of objects into groups, when objects vary in several values of several properties and again when objects are regrouped.
- Demonstrate the ability to reason in terms of the union and intersection of sets.

**By the end of grade 12, students should be able to:**

- Use conventional systems and terms for labeling or naming objects, materials, categories, etc.
- Locate and use print and non-print materials related to classification skills.
- Devise codes or systems for personal organization, storage and retrieval of information.
- Modify classification schemes as needed to accommodate new or complex information.

## **5d) MEASURING**

Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child.

The school Science Education Program should promote the measuring skills by providing as many developmental experiences as necessary.

**By the end of kindergarten, students should be able to:**

- Compare properties of two objects or events.
- Order a group of objects from most to least or vice versa using a property of those objects or systems.

**By the end of grade 1, students should be able to:**

- Measure an object using nonstandard and standard measurements.

**By the end of grade 2, students should be able to:**

- Use the appropriate instrument for making a particular measurement.

**By the end of grade 3, students should be able to:**

- Measure length, capacity, and weight in U.S. customary and metric units.
- Select the appropriate units for making a particular measurement.
- Measure some property of an object using arbitrary units (e.g. volume can be measured by using milliliters or fluid ounces.)

**By the end of grade 4, students should be able to:**

- Select and apply appropriate U.S. customary and metric units/tools to measure to the degree of accuracy needed.
- Make a simple scale diagram.

**By the end of grade 5, students should be able to:**

- Select and correctly use the appropriate metric device to measure distance, mass, volume, temperature or other physical quantities
- Explain the limitations and/or degree of precision of common home and scientific laboratory devices.
- Estimate and calculate relative measurements of time, length, mass, volume, and temperature.

**By the end of grade 8, students should be able to:**

- Select a measurement that is more precise than another measurement.
- Identify the accuracy of derived values, given the accuracy of the measured variable.
- Differentiate between direct and indirect measurements (e.g. density is an indirect measurement.)
- Measure objects by making relative comparisons (e.g. ratio and proportions.)
- Apply their understanding of metric, non-standard and English units of measure to accurately collect data in a scientific investigation.
- Demonstrate an understanding of metric prefixes through numeral value and scientific notation.

**By the end of grade 12, students should be able to:**

- Use a variety of measurement instruments needed in inquiry.
- Select and use appropriate units and procedures for measuring properties and quantitatively documenting observations.
- Make logical estimates based on available measurement information.
- Distinguish between estimates and predictions where estimates are relatively rough approximations while predictions are based on accurate, systematic processing of valid data, mathematical projections, and other evidence.
- Distinguish between multi-component measures, such as vectors, and single component measures.
- Select and use appropriate scientific notations for accurately recording measurements.
- Demonstrate understanding of some relatively subject-specific standardized unit of measurements. Some examples include: time, energy, power, force, electrical potential, charge, temperature and bits.

**5e) MODEL BUILDING**

Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g. chart, diagram diorama, scale model, dramatization, etc.). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.

**By the end of kindergarten, students should be able to:**

- Explain an idea or observation in a picture or through a dramatization.

**By the end of grade 1, students should be able to:**

- Identify characteristics of models (a model represents an object or process and helps to explain how it functions.)
- Create simple models (e.g. dioramas).
- Create simple charts and graphics with appropriate labels.

**By the end of grade 2, students should be able to:**

- Create graphics and models to demonstrate their knowledge.

**By the end of grade 3, students should be able to:**

- Create graphics and/or models to explain their understanding of science concepts (i.e. structures and functions in organisms, sound vibrations).
- Use a model of a simple machine.

**By the end of grade 4, students should be able to:**

- Represent a scientific model pictorially.
- Create a simple model of a scientific concept, such as an electric circuit.

**By the end of grade 5, students should be able to:**

- Identify advantages of models and simulations.
- Use models and/or simulations to represent and investigate scientific concepts.
- Construct models or create simulations to explain scientific concepts.
- Create a simple scale drawing of an object or event.
- Identify two models, which could explain the same phenomenon.

**By the end of grade 8, students should be able to:**

- Support and explain scientific data using scale and mathematical models.
- Distinguish between a scientific model and the observation from which the model was derived.
- Test a given model or one's own model experimentally.
- Identify whether or not a given model is satisfactory, given the results of the tests.

**By the end of grade 12, students should be able to:**

- Decode scientific information represented in models.
- Distinguish between the various scientific uses of the term “model,” based on the context in which it is used.
  - ~ Mental models being frames of reference or cognitive schemes: the sets of definitions, principles, and criteria by which we mentally organize information.
  - ~ Procedural models being sets of conventionalized principles, strategies, and instruments used for inquiry or problem solution.
  - ~ Constructed models being displays of graphics, objects or dynamic representations of ideas about reality.
  - ~ Theoretical models being interpretative schemes or constructs: sets of ideas based on assumptions, which explain observations by identifying factors and hypothesizing relationships.

- Alter or expand mental models to accommodate newly validated scientific information.
- Select and follow procedural models, which are appropriate purposes of inquiries.
- Distinguish between theoretical construct and the reality of observations the theory attempts to explain.
- Define relationships between scientific law and theory.
- Shape theory according to experiment.

## 6) USING SCIENTIFIC VOCABULARY

The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with efficiency and clarity.

The school Science Education Program should encourage students to use appropriate scientific vocabulary.

**By the end of grades K, 1, 2, and 3, students should be able to:**

- Use measurement terms and symbols accurately for their level (e.g. weather symbols, symbol for degrees, periodic table symbols).
- Recognize and use scientific terms appropriate for their grade level.

**By the end of grades 5, 8, and 12, students should be able to:**

- Recognize the need for standardization of scientific terms, symbols, and measurement units.
- Understand that definitions of scientific terms may be refined/enhanced.
- Use accurate scientific names for organisms and objects, appropriate for their grade level.
- Use scientific terms accurately (e.g. hypothesis and prediction).
- Use scientific terms specifically for the concept involved (e.g. *mass* instead of *weight* and *density* instead of *weight*).
- Locate and use resources for defining and clarifying scientific vocabulary.

## 7) COMMUNICATING

Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. This is done through activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting.

The school Science Education Program should provide students with many opportunities to communicate ideas with others.

**By the end of kindergarten, students should be able to:**

- Ask questions about the world around them based on observations and using the appropriate senses.

**By the end of grade 1, students should be able to:**

- Explain the results of an investigation to an audience using simple data organizers (e.g. charts, graphs, pictures).

**By the end of grade 2, students should be able to:**

- Listen attentively to reports given by others.
- Ask questions to help clarify and/or expand on ideas.

**By the end of grade 3, students should be able to:**

- Communicate feelings and values orally and in writing.
- Communicate concepts and data through various formats (i.e. graphs, drawings, or displays.)
- Pose relevant questions that will lead to a hypothesis.

**By the end of grade 4, students should be able to:**

- Share ideas through discussions and/or reporting in large as well as small groups.
- Listen objectively to distinguish between fact and opinion, observation and inference.

**By the end of grade 5, students should be able to:**

- Participate effectively in group inquiries or problem solutions (e.g. contribute ideas and work cooperatively.)
- Communicate and defend conclusions based on evidence (through written or oral reports.)
- Ask questions to clarify their own perception of another person's feelings or intentions.

**By the end of grade 8, students should be able to:**

- Use mathematical concepts and symbols in data analysis to support explanations and conclusions.
- Identify factors, which contribute to accuracy and relevance in communication between individuals.
- Communicate the significant components of the experimental design and results of a scientific investigation

**By the end of grade 12, students should be able to:**

- Communicate the components of a scientific investigation, using appropriate format, for the intended purpose.
- Defend and support conclusions, explanations, and arguments based on logic, scientific knowledge, and evidence from data.
- Engage in and explain the importance of peer review in science.
- Explain how scientific explanations must meet a set of established criteria to be considered valid.

## 8) USING SPACE-TIME RELATIONSHIPS

Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling and time.

The school Science Education Program should build for understanding of these concepts by providing students the necessary developmental learning experiences.

**By the end of kindergarten, students should be able to:**

- Identify a two-dimensional object.
- Identify the shapes of various objects in their environment.
- Order a set of events in terms of the time order in which three events occurred.

**By the end of grade 1, students should be able to:**

- Identify a three-dimensional object.
- Distinguish between figures that have symmetry and those that do not.
- Use positional and directional words such as *left* or *right*, *above* or *below*, *in front of* or *behind* to describe or identify the position of an object relative to another object.
- Construct and use simple maps to represent space relationships.

**By the end of grade 2, students should be able to:**

- Identify the position of an object relative to several other objects at the same time.

**By the end of grade 3, students should be able to:**

- Tell whether an object in a series has moved up, down, forward, backward, or left, right.
- Describe the changes in the position of an object in reference to itself or another object.

**By the end of grade 4, students should be able to:**

- Demonstrate an understanding of points, lines, planes, spaces and angles.
- Describe how a scene would look when viewed from a position other than its present position.
- Identify from a picture drawn in perspective the object that is closer to or farther away from a given point.

**By the end of grade 5, students should be able to:**

- Read a distance scale on a map and give the distance from one point to another.
- Measure time in units appropriate for the activity—minutes, hour, day, year, season, etc.
- Compare relative speed of objects in motion.

**By the end of grade 8, students should be able to:**

- Draw a map of a scene to scale.
- Use cardinal (principal) directions when identifying the route between given locations on a map.

- Demonstrate an understanding of the coordinate system.
- Describe how a scene would look like if seen from a position other than one's own.
- Move an object or identify movement in a given angular or linear direction.

**By the end of grade 12, students should be able to:**

- Use angular measurements to identify position and to identify the difference between two positions.
- Describe relationships between time measurements and other spatial measurements.

## 9) PROCESS INTEGRATION

Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge, and attitudes and apply them to a unique or original situation to solve a problem.

The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.

**By the end of grade 2, students should be able to:**

- Engage in problem solving appropriate to their level.

**By the end of grade 5, students should be able to:**

- Construct and devise an investigation about observed phenomena, including the development of a hypothesis and identifying and controlling variables.
- Identify the other processes of science and mathematics as applied in the investigation.
- Conduct and report in writing the results of the investigation.

**By the end of grade 8, students should be able to:**

- Identify a scientific problem to be investigated, propose or identify a testable hypothesis and devise an appropriate experimental design to collect data to answer the question.
- Identify the process of applying generalizations to the interpretation of information as deduction (deductive logic, deductive reasoning).

**By the end of grade 12, students should be able to:**

- Identify the process of generalization from interpretation of information as induction (inductive logic, inductive reasoning).
- Apply generalizations, which are appropriate to the content covered and to deductive inquiry.
- Describe ways in which generalizing relates to other inquiry processes like abstracting, summarizing, associating, and synthesizing



## APPENDIX B: SCIENCE PROCESS SKILLS BY GRADE LEVEL

KINDERGARTEN		
<i>Skill</i>	<i>Description of Process Skill</i>	<i>Grade Level Expectation</i>
<b>Observing</b>	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	<b>By the end of kindergarten, students should be able to:</b> <ul style="list-style-type: none"> <li>• Use senses to make observations about the world around them.</li> <li>• Identify objects and their properties (color, shape, texture, size, sound, quantity, etc.) using their five senses.</li> <li>• Identify likenesses and differences in a variety of objects.</li> <li>• Observe and describe changes in the properties of objects.</li> </ul>
<b>Questioning, Inferring, and Predicting</b>	<p>Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect or to answer a question. Inferring involves interpretation of observations.</p> <p>Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.</p>	<b>By the end of kindergarten, students should be able to:</b> <ul style="list-style-type: none"> <li>• Ask questions when they observe the world around them.</li> </ul>
<b>Making, Selecting, and Testing Hypotheses</b>	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.	<b>By the end of kindergarten, students should be able to:</b> <ul style="list-style-type: none"> <li>• Identify or make a guess about the cause of an event.</li> </ul>
<b>Identifying and Controlling Variables</b>	Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them.	<b>By the end of kindergarten, the student should be able to:</b> <ul style="list-style-type: none"> <li>• Make observations about variables that affect a result (e.g., sun = hot).</li> </ul>
The school Science Education Program should provide students with many investigative/ experimental		

<b><i>Skill</i></b>	<b><i>Description of Process Skill</i></b>	<b><i>Grade Level Expectation</i></b>
<b>Identifying and Controlling Variables</b>	<p>experiences in order to help develop skills in identifying and controlling variables.</p> <p>Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them.</p> <p>The school Science Education Program should provide students with many investigative/experimental experiences in order to help develop skills in identifying and controlling variables.</p>	<p><b>By the end of kindergarten, the student should be able to:</b></p> <ul style="list-style-type: none"> <li>• Make observations about variables that affect a result (e.g., sun = hot).</li> </ul>
<b>Collecting, Recording, Organizing, and Interpreting Data</b>	<p>Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table.</p> <p>The school Science Education Program should provide the necessary experiences for students to develop skills in handling and interpreting data.</p>	<p><b>By the end of kindergarten, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Collect data using the 5 senses.</li> </ul>
<b>Graphing</b>	<p>Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph.</p> <p>The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill.</p>	<p><b>By the end of kindergarten, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Sort living and non-living things according to stated attributes</li> </ul>
<b>Using Equipment and Apparatus</b>	<p>The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use.</p>	<p><b>By the end of kindergarten, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Maintain a safe and healthy classroom environment at all times</li> </ul>

<b><i>Skill</i></b>	<b><i>Description of Process Skill</i></b>	<b><i>Grade Level Expectation</i></b>
	The school Science Education Program should provide students with many hands-on experiences in the use of science equipment and apparatus.	
<b>Classifying</b>	The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into groups or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out.  The Science Education Program should determine to what extent classification skills can be carried out. The school Science Education Program should promote the classification skills by providing as many developmental experiences as necessary.	<p><b>By the end of kindergarten, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Classify or sort objects or events by their properties.</li> <li>Use given or student-generated criteria to sort objects.</li> </ul>
<b>Measuring</b>	Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child. The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.	<p><b>By the end of kindergarten, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Compare properties of two objects or events.</li> <li>Order a group of objects from most to least or vice versa using a property of those objects or systems.</li> </ul>
<b>Model Building</b>	Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g., chart, diagram, diorama, scale model, dramatization, etc.). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.	<p><b>By the end of kindergarten, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Explain an idea or observation in a picture or through a dramatization.</li> </ul>
<b>Using Scientific Vocabulary</b>	The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with	<p><b>By the end of kindergarten, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Use measurement terms and symbols accurately for their level</li> </ul>

## Appendix B

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
	<p>efficiency and clarity.</p> <p>The school Science Education Program should encourage students to use appropriate scientific vocabulary.</p>	<p>(e.g., weather symbols, symbol for degrees, periodic table symbols).</p> <ul style="list-style-type: none"> <li>Recognize and use scientific terms appropriate for their grade level.</li> </ul>
<b>Communicating</b>	<p>Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting.</p> <p>The school Science Education Program should provide students with many opportunities to communicate ideas with others.</p>	<p><b>By the end of kindergarten, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Ask questions about the world around them based on observations and using the appropriate senses.</li> </ul>
<b>Using Space-Time Relationships</b>	<p>Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling and time.</p> <p>The school Science Education Program should build an understanding of these concepts by providing students the necessary developmental learning experiences.</p>	<p><b>By the end of kindergarten, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Identify a two-dimensional object.</li> <li>Identify the shapes of various objects in their environment.</li> <li>Order a set of events in terms of the time order in which three events occurred.</li> </ul>
<b>Process Integration</b>	<p>Process integration involves the ability to synthesize the skills learned to solve problems (i.e. knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge, and attitudes and apply them to a unique or original situation to solve a problem.</p> <p>The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.</p>	<p><b>By the end of kindergarten, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Engage in problem solving appropriate to their level.</li> </ul>

**GRADE 1**

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
<b>Observing</b>	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	<b>By the end of grade 1, students should be able to:</b> <ul style="list-style-type: none"> <li>• Use appropriate language when describing an object or making an observation (e.g., Is the object larger in length, width, and weight?)</li> <li>• State objects in quantitative terms whenever possible.</li> <li>• State objects in qualitative terms whenever possible.</li> </ul>
<b>Questioning, Inferring, and Predicting</b>	Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations.  Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.	<b>By the end of grade 1, students should be able to:</b> <ul style="list-style-type: none"> <li>• Collect data to answer their questions.</li> </ul>
<b>Making, Selecting, and Testing Hypotheses</b>	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.	<b>By the end of grade 1, students should be able to:</b> <ul style="list-style-type: none"> <li>• Make guesses and give reasons or data to support their guess.</li> </ul>
<b>Identifying and Controlling Variables</b>	Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them.  The school Science Education Program should provide students with many investigative/experimental experiences in order to help develop skills in identifying and controlling variables.	<b>By the end of grade 1, the student should be able to:</b> <ul style="list-style-type: none"> <li>• Identify things or events that can change an outcome.</li> </ul>

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
<b>Collecting, Recording, Organizing, and Interpreting Data</b>	Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table.	<b>By the end of grade 1, students should be able to:</b> <ul style="list-style-type: none"> <li>Collect, record, and organize data using simple tools, equipment, techniques.</li> <li>Explain results using simple data organizers.</li> </ul>
<b>Graphing</b>	<p>The school Science Education Program should provide the necessary experiences for their students to develop skills in handling and interpreting data.</p> <p>Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph.</p> <p>The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill.</p>	<b>By the end of grade 1, students should be able to:</b> <ul style="list-style-type: none"> <li>Construct and interpret simple graphs.</li> </ul>
<b>Using Equipment and Apparatus</b>	<p>The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery involves effective and efficient use.</p> <p>The school Science Education Program should provide our students with many hands-on experiences in the use of science equipment and apparatus.</p>	<b>By the end of grade 1, students should be able to:</b> <ul style="list-style-type: none"> <li>Properly retrieve, store, and maintain science equipment and supplies.</li> </ul>
<b>Classifying</b>	<p>The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into groups or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out.</p> <p>The Science Education Program should determine to what extent classification skills can be carried out. The school</p>	<b>By the end of grade 1, students should be able to:</b> <ul style="list-style-type: none"> <li>Classify the same group of objects in several different ways.</li> <li>Use student-generated criteria to sort objects.</li> </ul>

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
	Science Education Program should promote classification skills by providing as many developmental experiences as necessary.	
<b>Measuring</b>	Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child.	<p><b>By the end of grade 1, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Measure an object using nonstandard and standard measurements.</li> </ul>
	The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.	
<b>Model Building</b>	Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g. chart, diagram, diorama, scale model, dramatization). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.	<p><b>By the end of grade 1, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Identify characteristics of models (a model represents an object or process and helps to explain how it functions.)</li> <li>• Create simple models (e.g., dioramas).</li> <li>• Create simple charts and graphics with appropriate labels.</li> </ul>
<b>Using Scientific Vocabulary</b>	The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with efficiency and clarity.	<p><b>By the end of grade 1, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Use measurement terms and symbols accurately for their level (e.g., weather symbols, symbol for degrees, periodic table symbols).</li> <li>• Recognize and use scientific terms appropriate for their grade level.</li> </ul>
<b>Communicating</b>	The school Science Education Program should encourage students to use appropriate scientific vocabulary.	
	Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting.	<p><b>By the end of grade 1, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Explain the results of an investigation to an audience using simple data organizers (e.g. charts, graphs, pictures).</li> </ul>
	The school Science Education Program should provide students with many opportunities to communicate ideas with others.	

## Appendix B

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
<b>Using Space-Time Relationships</b>	<p>Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling and time.</p> <p>The school Science Education Program should build for understanding of these concepts by providing students the necessary developmental learning experiences.</p>	<p><b>By the end of grade 1, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• a three-dimensional object.</li> <li>• Distinguish between figures that have symmetry and those that do not.</li> <li>• Use positional and directional words such as left or right, above or below, in front of or behind to describe or identify the position of an object relative to another object.</li> <li>• Construct and use simple maps to represent space relationships.</li> </ul>
<b>Process Integration</b>	<p>Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge, and attitudes and apply them to a unique or original situation to solve a problem.</p> <p>The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.</p>	<p><b>By the end of grade 1, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Engage in problem solving appropriate to their level.</li> </ul>



**GRADE 2**

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
<b>Observing</b>	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	<b>By the end of grade 2, students should be able to:</b> <ul style="list-style-type: none"> <li>Identify the difference between statements of observation and opinion.</li> </ul>
<b>Questioning, Inferring, and Predicting</b>	<p>Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations.</p> <p>Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.</p>	<b>By the end of grade 2, students should be able to:</b> <ul style="list-style-type: none"> <li>Make a prediction based on observation.</li> </ul>
<b>Making, Selecting, and Testing Hypotheses</b>	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.	<b>By the end of grade 2, students should be able to:</b> <ul style="list-style-type: none"> <li>Conduct a simple investigation to test a prediction.</li> </ul>
<b>Identifying and Controlling Variables</b>	<p>Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them.</p> <p>The school Science Education Program should provide students with many investigative/experimental experiences in order to help develop skills in identifying and controlling variables.</p>	<b>By the end of grade 2, the student should be able to:</b> <ul style="list-style-type: none"> <li>Replicate a simple investigation by changing one part of the procedure (variable) at a time to get a different outcome.</li> </ul>

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
<b>Collecting, Recording, Organizing, and Interpreting Data</b>	Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table.  The school Science Education Program should provide the necessary experiences for their students to develop skills in handling and interpreting data.	<b>By the end of grade 2, students should be able to:</b> <ul style="list-style-type: none"> <li>Communicate results of observations and simple investigations.</li> </ul>
<b>Graphing</b>	Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph.  The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill.	<b>By the end of grade 2, students should be able to:</b> <ul style="list-style-type: none"> <li>Construct and accurately label data organizers to show data collected in a simple investigation.</li> </ul>
<b>Using Equipment and Apparatus</b>	The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use.  The school Science Education Program should provide our students with many hands-on experiences in the use of science equipment and apparatus.	<b>By the end of grade 2, students should be able to:</b> <ul style="list-style-type: none"> <li>Recognize the names and functions of various instruments used in class.</li> </ul>
<b>Classifying</b>	The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into group or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out.  The Science Education Program should determine to what extent classification skills can be carried out. The school	<b>By the end of grade 2, students should be able to:</b> <ul style="list-style-type: none"> <li>Organize and analyze the classification of objects (living and non-living) in a matrix.</li> </ul>

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
	Science Education Program should promote classification skills by providing as many developmental experiences as necessary.	
<b>Measuring</b>	Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child.	<p><b>By the end of grade 2, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Use the appropriate instrument for making a particular measurement.</li> </ul>
	The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.	
<b>Model Building</b>	Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g., chart, diagram, diorama, scale model, dramatization). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.	<p><b>By the end of grade 2, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Create graphics and models to demonstrate their knowledge.</li> </ul>
<b>Using Scientific Vocabulary</b>	The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with efficiency and clarity.	<p><b>By the end of grade 2, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Use measurement terms and symbols accurately for their level (e.g., weather symbols, symbol for degrees, periodic table symbols).</li> <li>Recognize and use scientific terms appropriate for their grade level.</li> </ul>
	The school Science Education Program should encourage students to use appropriate scientific vocabulary.	
<b>Communicating</b>	Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting.	<p><b>By the end of grade 2, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Listen attentively to reports given by others.</li> <li>Ask questions to help clarify and/or expand on ideas.</li> </ul>
	The school Science Education Program should provide students with many opportunities to communicate ideas with others.	

<b><i>Skill</i></b>	<b><i>Description of Process Skill</i></b>	<b><i>Grade Level Expectation</i></b>
<b>Using Space-Time Relationships</b>	<p>Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling, and time.</p> <p>The school Science Education Program should build understanding of these concepts by providing students with the necessary developmental learning experiences.</p>	<p><b>By the end of grade 2, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Identify the position of an object relative to several other objects at the same time.</li> </ul>
<b>Process Integration</b>	<p>Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge and attitudes and apply them to a unique or original situation to solve a problem.</p> <p>The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.</p>	<p><b>By the end of grade 2, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Engage in problem solving appropriate to their level.</li> </ul>

**GRADE 3**

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
<b>Observing</b>	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	<b>By the end of grade 3, students should be able to:</b> <ul style="list-style-type: none"> <li>• Use the appropriate senses to collect data to answer a question.</li> </ul>
<b>Questioning, Inferring, and Predicting</b>	<p>Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations.</p> <p>Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.</p>	<b>By the end of grade 3, students should be able to:</b> <ul style="list-style-type: none"> <li>• Pose relevant questions based on observations.</li> <li>• Collect and analyze data to answer the question(s).</li> </ul>
<b>Making, Selecting, and Testing Hypotheses</b>	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.	<b>By the end of grade 3, students should be able to:</b> <ul style="list-style-type: none"> <li>• Develop a hypothesis that relates to an observation.</li> </ul>
<b>Identifying and Controlling Variables</b>	<p>Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them.</p> <p>The school Science Education Program should provide students with many investigative/experimental experiences in order to help develop skills in identifying and controlling variables.</p>	<b>By the end of grade 3, the student should be able to:</b> <ul style="list-style-type: none"> <li>• Collect and analyze data to answer a question.</li> <li>• Identify variables that could affect an outcome.</li> </ul>

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
<b>Collecting, Recording, Organizing, and Interpreting Data</b>	Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table.	<b>By the end of grade 3, students should be able to:</b> <ul style="list-style-type: none"> <li>• Make graphic organizers to analyze systems and/or the results of investigations.</li> <li>• Identify data to be collected to answer questions about the investigation.</li> </ul>
<b>Graphing</b>	<p>The school Science Education Program should provide the necessary experiences for students to develop skills in handling and interpreting data.</p> <p>Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph.</p> <p>The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill.</p>	<b>By the end of grade 3, students should be able to:</b> <ul style="list-style-type: none"> <li>• Identify different graphs and use them to organize data.</li> <li>• Interpret and answer questions about data represented in graphs.</li> </ul>
<b>Using Equipment and Apparatus</b>	<p>The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use.</p> <p>The school Science Education Program should provide students with many hands-on experiences in the use of science equipment and apparatus.</p>	<b>By the end of grade 3, students should be able to:</b> <ul style="list-style-type: none"> <li>• Follow conventional procedures for effective use of equipment and apparatus.</li> </ul>
<b>Classifying</b>	<p>The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into groups or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out.</p> <p>The Science Education Program should determine to what extent classification skills can be carried out. The school</p>	<b>By the end of grade 3, students should be able to:</b> <ul style="list-style-type: none"> <li>• Decide ways in which a group of objects are similar or different, and then identify another group of objects that are similar or different in the same way.</li> </ul>

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
	Science Education Program should promote classification skills by providing as many developmental experiences as necessary.	
<b>Measuring</b>	Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child.	<p><b>By the end of grade 3, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Measure length, capacity, and weight in U.S. customary and metric units.</li> <li>• Select the appropriate units for making a particular measurement.</li> <li>• Measure some property of an object using arbitrary units (e.g., volume can be measured by using milliliters or fluid ounces.)</li> </ul>
	The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.	
<b>Model Building</b>	Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g., chart, diagram, diorama, scale model, dramatization). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.	<p><b>By the end of grade 3, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Create graphics and/or models to explain their understanding of science concepts (e.g., structures and functions in organisms, sound vibrations).</li> <li>• Use a model of a simple machine.</li> </ul>
<b>Using Scientific Vocabulary</b>	The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with efficiency and clarity.	<p><b>By the end of grade 3, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Use measurement terms and symbols accurately for their level (e.g., weather symbols, symbol for degrees, periodic table symbols).</li> <li>• Recognize and use scientific terms appropriate for their grade level.</li> </ul>
	The school Science Education Program should encourage students to use appropriate scientific vocabulary.	
<b>Communicating</b>	Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting.	<p><b>By the end of grade 3, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Communicate feelings and values orally and in writing.</li> <li>• Communicate concepts and data through various formats (i.e., graphs, drawings, or displays).</li> <li>• Pose relevant questions that will lead to a hypothesis.</li> </ul>
	The school Science Education Program should provide students with many opportunities to communicate ideas with others.	

## Appendix B

<b><i>Skill</i></b>	<b><i>Description of Process Skill</i></b>	<b><i>Grade Level Expectation</i></b>
<b>Using Space-Time Relationships</b>	<p>Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling, and time.</p> <p>The school Science Education Program should build for understanding of these concepts by providing students the necessary developmental learning experiences.</p>	<p><b>By the end of grade 3, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Tell whether an object in a series has moved up, down, forward, backward, or left, right.</li> <li>• Describe the changes in the position of an object in reference to itself or another object.</li> </ul>
<b>Process Integration</b>	<p>Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge, and attitudes and apply them to a unique or original situation to solve a problem.</p> <p>The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.</p>	<p><b>In grade 3, students should be developing skills to:</b></p> <ul style="list-style-type: none"> <li>• Construct and devise an investigation about observed phenomena, including the development of a hypothesis and identifying and controlling variables.</li> <li>• Identify the other processes of science and mathematics as applied in the investigation.</li> <li>• Conduct and report in writing the results of the investigation.</li> </ul>



**GRADE 4**

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
<b>Observing</b>	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	<p><b>By the end of grade 4, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Distinguish between an observation and an inference.</li> </ul>
<b>Questioning, Inferring, and Predicting</b>	<p>Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations.</p> <p>Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.</p>	<p><b>By the end of grade 4, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Distinguish between an observation and an inference.</li> </ul>
<b>Making, Selecting, and Testing Hypotheses</b>	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.	<p><b>By the end of grade 4, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Distinguish between statements that are testable hypotheses and those that are not.</li> </ul>
<b>Identifying and Controlling Variables</b>	<p>Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them.</p> <p>The school Science Education Program should provide students with many investigative/experimental experiences in order to help develop skills in identifying and controlling variables.</p>	<p><b>By the end of grade 4, the student should be able to:</b></p> <ul style="list-style-type: none"> <li>Identify variables in an experimental procedure.</li> <li>Identify the variables that must stay the same if the experiment is repeated.</li> </ul>

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
<b>Collecting, Recording, Organizing, and Interpreting Data</b>	Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table.	<b>By the end of grade 4, students should be able to:</b> <ul style="list-style-type: none"> <li>Identify data to be collected in an experimental procedure and communicate it in written or verbal form.</li> <li>Analyze data from a table or chart to make inferences or draw conclusions.</li> </ul>
<b>Graphing</b>	<p>The school Science Education Program should provide the necessary experiences for students to develop skills in handling and interpreting data.</p> <p>Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph.</p> <p>The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill</p>	<b>By the end of grade 4, students should be able to:</b> <ul style="list-style-type: none"> <li>Describe relationships of components illustrated in various graphs.</li> </ul>
<b>Using Equipment and Apparatus</b>	<p>The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use.</p> <p>The school Science Education Program should provide students with many hands-on experiences in the use of science equipment and apparatus.</p>	<b>By the end of grade 4, students should be able to:</b> <ul style="list-style-type: none"> <li>Use appropriate instruments for making a particular measurement or doing a particular experiment.</li> </ul>
<b>Classifying</b>	<p>The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into group or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out.</p> <p>The Science Education Program should determine to what extent classification skills can be carried out. The</p>	<b>By the end of grade 4, students should be able to:</b> <ul style="list-style-type: none"> <li>Create and analyze the classification of objects (living and non-living) in a matrix.</li> </ul>

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
	school Science Education Program should promote classification skills by providing as many developmental experiences as necessary.	
<b>Measuring</b>	<p>Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects.</p> <p>Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child. The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.</p>	<p><b>By the end of grade 4, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Select and apply appropriate U.S. customary and metric units/tools to measure to the degree of accuracy needed.</li> <li>• Make a simple scale diagram.</li> </ul>
<b>Model Building</b>	Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g., chart, diagram, diorama, scale model, dramatization). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.	<p><b>By the end of grade 4, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Represent a scientific model pictorially.</li> <li>• Create a simple model of a scientific concept, such as an electric circuit.</li> </ul>
<b>Using Scientific Vocabulary</b>	<p>The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with efficiency and clarity.</p> <p>The school Science Education Program should encourage students to use appropriate scientific vocabulary.</p>	<p><b>By the end of grade 4, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Recognize the need for standardization of scientific terms, symbols, and measurement units.</li> <li>• Understand that definitions of scientific terms may be refined/enhanced.</li> <li>• Use accurate scientific names for organisms and objects, appropriate for their grade level.</li> <li>• Use scientific terms accurately (e.g., <i>hypothesis</i> and <i>prediction</i>).</li> <li>• Use scientific terms specifically for the concept involved (e.g. <i>mass</i> instead of <i>weight</i> and <i>density</i> instead of <i>weight</i>).</li> <li>• Locate and use resources for defining and clarifying scientific vocabulary</li> <li>• .</li> </ul>

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
<b>Communicating</b>	Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting.  The school Science Education Program should provide students with many opportunities to communicate ideas with others.	<p><b>By the end of grade 4, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Share ideas through discussions and/or reporting in large as well as small groups.</li> <li>• Listen objectively to distinguish between fact and opinion, observation and inference.</li> </ul>
<b>Using Space-Time Relationships</b>	Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling and time.  The school Science Education Program should build for understanding of these concepts by providing students the necessary developmental learning experiences.	<p><b>By the end of grade 4, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Demonstrate an understanding of points, lines, planes, spaces and angles.</li> <li>• Describe how a scene would look when viewed from a position other than its present position.</li> <li>• Identify from a picture drawn in perspective the object that is closer to or farther away from a given point.</li> </ul>
<b>Process Integration</b>	Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge and attitudes and apply them to a unique or original situation to solve a problem.  The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.	<p><b>In grade 4 students should be developing skills to:</b></p> <ul style="list-style-type: none"> <li>• Construct and devise an investigation about observed phenomena, including the development of a hypothesis and identifying and controlling variables.</li> <li>• Identify the other processes of science and mathematics as applied in the investigation.</li> <li>• Conduct and report in writing the results of the investigation.</li> </ul>

**GRADE 5**

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
<b>Observing</b>	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	<b>By the end of grade 5, students should be able to:</b> <ul style="list-style-type: none"> <li>• Use observations to collect data in a scientific investigation.</li> </ul>
<b>Questioning, Inferring, and Predicting</b>	<p>Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations.</p> <p>Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.</p>	<b>By the end of grade 5, students should be able to:</b> <ul style="list-style-type: none"> <li>• Construct one or more inferences from observations.</li> <li>• Identify observations which support an inference.</li> </ul>
<b>Making, Selecting, and Testing Hypotheses</b>	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened	<b>By the end of grade 5, students should be able to:</b> <ul style="list-style-type: none"> <li>• Construct a hypothesis from a set of observations and inferences.</li> <li>• Devise and conduct a test or tests for the formulated hypothesis.</li> <li>• Choose an appropriate type of apparatus to be used to test a given hypothesis.</li> </ul>
<b>Identifying and Controlling Variables</b>	<p>Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them.</p> <p>The school Science Education Program should provide students with investigative/experimental experiences to develop skills in identifying and controlling variables</p>	<b>By the end of grade 5, the student should be able to:</b> <ul style="list-style-type: none"> <li>• Name variables that have affected or may affect the outcome of an investigation.</li> <li>• Identify and name which variable should be controlled and manipulated in an investigation.</li> </ul>

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
<b>Collecting, Recording, Organizing, and Interpreting Data</b>	Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table.  The school Science Education Program should provide the necessary experiences for their students to develop skills in handling and interpreting data.	<b>By the end of grade 5, students should be able to:</b> <ul style="list-style-type: none"> <li>Sequence observed changes in materials and systems both verbally and in writing.</li> <li>Organize collected data in tables, graphs, histograms, and/or matrices, to display and/or infer trends.</li> <li>Research and use accurate and technical information.</li> <li>Use data collected to formulate and defend conclusions.</li> </ul>
<b>Graphing</b>	Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph.  The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill.	<b>By the end of grade 5, students should be able to:</b> <ul style="list-style-type: none"> <li>Select appropriate graph(s) to depict the data collected.</li> <li>Construct, label, and interpret simple line graphs, bar graphs, and circle graphs.</li> </ul>
<b>Using Equipment and Apparatus</b>	The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use.  The School Science Education Program should provide students with many hands-on experiences in the use of science equipment and apparatus.	<b>By the end of grade 5, students should be able to:</b> <ul style="list-style-type: none"> <li>Adapt or modify standard science procedures or equipment as needed, keeping safety in mind at all times.</li> </ul>
<b>Classifying</b>	The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into group or categories according to characteristic properties. The experience level determines to what extent classification skills can be carried out.  The Science Education Program should determine to what extent classification skills can be carried out. The	<b>By the end of grade 5, students should be able to:</b> <ul style="list-style-type: none"> <li>Classify one or more given subsystems within a corresponding system (i.e., circulatory, digestive, and respiratory systems are subsystems of the human body).</li> </ul>

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
<b>Measuring</b>	<p>school Science Education Program should promote classification skills by providing as many developmental experiences as necessary</p> <p>Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child.</p> <p>The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.</p>	<p><b>By the end of grade 5, students should be able to:.</b></p> <ul style="list-style-type: none"> <li>• Select and correctly use the appropriate metric device to measure distance, mass, volume, temperature or other physical quantities.</li> <li>• Explain the limitations and/or degree of precision of common home and scientific laboratory devices.</li> <li>• Estimate and calculate relative measurements of time, length, mass, volume, and temperature.</li> </ul>
<b>Model Building</b>	<p>Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g., chart, diagram, diorama, scale model, dramatization). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle.</p>	<p><b>By the end of grade 5, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Identify advantages of models and simulations.</li> <li>• Use models and/or simulations to represent and investigate scientific concepts.</li> <li>• Construct models or create simulations to explain scientific concepts.</li> <li>• Create a simple scale drawing of an object or event.</li> <li>• Identify two models, which could explain the same phenomenon.</li> </ul>
<b>Using Scientific Vocabulary</b>	<p>The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately and with efficiency and clarity.</p> <p>The school Science Education Program should encourage students to use appropriate scientific vocabulary.</p>	<p><b>By the end of grade 5, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Recognize the need for standardization of scientific terms, symbols, and measurement units.</li> <li>• Understand that definitions of scientific terms may be refined/enhanced.</li> <li>• Use accurate scientific names for organisms and objects, appropriate for their grade level.</li> <li>• Use scientific terms accurately (e.g., <i>hypothesis</i> and <i>prediction</i>).</li> <li>• Use scientific terms specifically for the concept involved (e.g., <i>mass</i> instead of <i>weight</i> and <i>density</i> instead of <i>weight</i>).</li> <li>• Locate and use resources for defining and clarifying scientific vocabulary.</li> </ul>

## Appendix B

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
<b>Communicating</b>	Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting.  The school Science Education Program should provide students with many opportunities to communicate ideas with others.	<b>By the end of grade 5, students should be able to:</b> <ul style="list-style-type: none"> <li>Participate effectively in group inquiries or problem solutions (e.g. contribute ideas and work cooperatively).</li> <li>Communicate and defend conclusions based on evidence (through written or oral reports).</li> <li>Ask questions to clarify their own perception of another person's feelings or intentions.</li> </ul>
<b>Using Space-Time Relationships</b>	Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling and time.  The school Science Education Program should build for understanding of these concepts by providing students the necessary developmental learning experiences.	<b>By the end of grade 5, students should be able to:</b> <ul style="list-style-type: none"> <li>Read a distance scale on a map, and give the distance from one point to another.</li> <li>Measure time in units appropriate for the activity—minutes, hour, day, year, season, etc.</li> <li>Compare relative speed of objects in motion.</li> </ul>
<b>Process Integration</b>	Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge and attitudes and apply them to a unique or original situation to solve a problem.  The school Science Education Program should provide students with many inquiry-based problem solving experiences. Students should be engaged in the entire scientific investigation process from observations through making conclusions to answer their questions.	<b>By the end of grade 5, students should be able to:</b> <ul style="list-style-type: none"> <li>Construct and devise an investigation about observed phenomena, including the development of a hypothesis and identifying and controlling variables.</li> <li>Identify the other processes of science and mathematics as applied in the investigation.</li> <li>Conduct and report in writing the results of the investigation.</li> </ul>



## MIDDLE SCHOOL (GRADES 6, 7, 8)

<i>Skill</i>	<i>Description of Process Skill</i>	<i>Grade Level Expectation</i>
<b>Observing</b>	Observing is a fundamental activity of scientists. Knowledge comes primarily from what we see, hear, taste, smell or touch. As children grow older and gain more experience, the details and accuracy of their observations increase. (Inference and opinions are not part of observing.)	<p><b>By the end of grade 8, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Describe objects qualitatively and quantitatively.</li> <li>Distinguish between relevant and irrelevant information in the description of an observation.</li> <li>Identify the unknown by comparing it to properties and/or characteristics of what is known.</li> <li>Use clear and accurate observations to explain science concepts.</li> </ul>
<b>Questioning, Inferring, and Predicting</b>	<p>Defining or thinking about the question must occur before an inference. Drawing an inference or inferring involves going beyond the information or evidence at hand to presume a cause or an effect, or to answer a question. Inference involves interpretation of observations.</p> <p>Predictions are inferences about future events that have been developed through observation and testing of current events. Predicting involves the skill of making informed estimates of what should happen in a given situation, based on knowledge of what enters into the situation and on previous experience.</p>	<p><b>By the end of grade 8, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Recognize when inferences need to be revised based on additional and more recent observations.</li> <li>Formulate a prediction based on a given set of observations.</li> <li>Conduct a test for predictions that have been made.</li> <li>Interpolate and extrapolate information from data.</li> </ul>
<b>Making, Selecting, and Testing Hypotheses</b>	Formulating and testing a hypothesis involve selecting the most probable solution (a tentative answer) that may have a cause and effect relationship within a problem. It involves doing something to see what happens and then recording what happened.	<p><b>By the end of grade 8, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Identify the degree of precision of measurement necessary for testing a simple hypothesis.</li> <li>Suggest or identify a test, which would support one hypothesis and weaken a competing hypothesis.</li> <li>Check that a hypothesis matches the existing information.</li> </ul>
<b>Identifying and Controlling Variables</b>	<p>Variables are conditions that can differ from one experiment or investigation within a system to another. Handling variables involves observation skills in identifying and naming variables related to the investigation and the ability to design ways of controlling them.</p> <p>The school Science Education Program should provide students with many investigative/experimental</p>	<p><b>By the end of grade 8, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Identify and name the manipulated and responding (independent and dependent) variables in an investigation.</li> </ul>

## Appendix B

<b><i>Skill</i></b>	<b><i>Description of Process Skill</i></b>	<b><i>Grade Level Expectation</i></b>
<b>Collecting, Recording, Organizing, and Interpreting Data</b>	<p>experiences in order to help develop skills in identifying and controlling variables.</p> <p>Organizing data involves the recording of observations and sequencing or ordering the data. These skills may involve the organization of data in terms of graphs and data tables. At the earlier stages of development, the skills may call for picture observation. In the upper grades, the student may be doing graphing, histograms, and taking measurements that require a data table.</p> <p>The school Science Education Program should provide the necessary experiences for their students to develop skills in handling and interpreting data.</p>	<p><b>By the end of grade 8, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Make a written report of an investigation, including: Background Information, Problem, Hypothesis, Materials and Methods, Results, Analysis, and Conclusion.</li> <li>• Identify and use the appropriate tools, equipment, and techniques to collect, display, and analyze data.</li> <li>• Represent and communicate data in multiple formats (verbal, written).</li> </ul>
<b>Graphing</b>	<p>Graphing involves the ability to organize raw data into picture or chart form using a graph, tally gram, pictograph, circle graph, or bar graph.</p> <p>The school Science Education Program should provide students with the necessary experiences in graph construction to develop this skill</p>	<p><b>By the end of grade 8, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Plot a set of points on a graph for a given set of data.</li> <li>• Construct a line graph, including the construction and labeling of axes, marking off units, plotting points, and drawing the line (or curve of best fit) for the graph.</li> <li>• Locate a specific piece of information on a line graph and/or bar graph.</li> <li>• Make inferences and logical conclusions for a given graph.</li> <li>• Make a prediction from a given line graph which shows a linear relationship between two variables.</li> </ul>
<b>Using Equipment and Apparatus</b>	<p>The proper selection and use of equipment requires skills just as the inquiry processes do. Proper use and handling involves safety considerations. Mastery of the instruments involves effective and efficient use.</p> <p>The school Science Education Program should provide students with many hands-on experiences in the use of science equipment and apparatus.</p>	<p><b>By the end of grade 8, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Recognize the appropriateness, limitations, and safety concerns of certain laboratory equipment.</li> <li>• Identify the names and function of various instruments and equipment used in the classroom.</li> </ul>
<b>Classifying</b>	<p>The process of classifying involves the examination of two or more objects or events to note similarities and differences in their properties and the systematic arrangement of those objects or events into group or categories according to characteristic properties. The</p>	<p><b>By the end of grade 8, students should be able to:</b></p> <ul style="list-style-type: none"> <li>• Divide objects into groups according to a hierarchical system by listing and identifying how many objects would be in a total set, given the properties of the objects in subsets and how many</li> </ul>

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
	<p>experience level determines to what extent classification skills can be carried out.</p> <p>The Science Education Program should determine to what extent classification skills can be carried out. The school Science Education Program should promote classification skills by providing as many developmental experiences as necessary.</p>	<ul style="list-style-type: none"> <li>objects would be in each subset.</li> <li>Identify the property which was used to divide a set of objects into groups, when objects vary in several values or several properties and again when objects are regrouped.</li> <li>Demonstrate the ability to reason in terms of the union and intersection of sets.</li> </ul>
<b>Measuring</b>	<p>Measuring is an activity that involves the comparison of certain properties of objects. It serves as a means of ordering events or objects. Measurement can be either qualitative or quantitative. The use of sophisticated tools of measurement as well as the accuracy of measurement is dependent upon the maturity and level of experience of the individual child.</p> <p>The school Science Education Program should promote measuring skills by providing as many developmental experiences as necessary.</p>	<p><b>By the end of grade 8, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Select a measurement that is more precise than another measurement.</li> <li>Identify the accuracy of derived values, given the accuracy of the measured variable.</li> <li>Differentiate between direct and indirect measurements (e.g. density is an indirect measurement).</li> <li>Measure objects by making relative comparisons (e.g., ratio and proportion).</li> <li>Apply their understanding of metric, non-standard and English units of measure to accurately collect data in a scientific investigation.</li> <li>Demonstrate an understanding of metric prefixes through numeral value and scientific notation.</li> </ul>
<b>Model Building</b>	<p>Model building involves pictures, drawings, graphics, objects, or dynamic representations of ideas about reality (e.g. chart, diagram, diorama, scale model, dramatization). On a simple level, models may merely be pictures explaining an idea or observation. On a higher level, it may involve a flow diagram or chart and, on an even higher level, it may represent a theory or principle</p>	<p><b>By the end of grade 8, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Support and explain scientific data using scale and mathematical models.</li> <li>Distinguish between a scientific model and the observation from which the model was derived.</li> <li>Test a given model or one's own model experimentally.</li> <li>Identify whether or not a given model is satisfactory, given the results of the tests.</li> </ul>
<b>Using Scientific Vocabulary</b>	<p>The proper use of scientific vocabulary involves using the appropriate terms to communicate ideas accurately, with efficiency and clarity.</p> <p>The school Science Education Program should encourage students to use appropriate scientific vocabulary.</p>	<p><b>By the end of grade 8, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Recognize the need for standardization of scientific terms, symbols, and measurement units.</li> <li>Understand that definitions of scientific terms may be refined/enhanced.</li> </ul>

## Appendix B

<b>Skill</b>	<b>Description of Process Skill</b>	<b>Grade Level Expectation</b>
		<ul style="list-style-type: none"> <li>Use accurate scientific names for organisms and objects, appropriate for their grade level.</li> <li>Use scientific terms accurately (e.g., <i>hypothesis</i> and <i>prediction</i>).</li> <li>Use scientific terms specifically for the concept involved (e.g., <i>mass</i> instead of <i>weight</i> and <i>density</i> instead of <i>weight</i>).</li> <li>Locate and use resources for defining and clarifying scientific vocabulary.</li> </ul>
<b>Communicating</b>	Communicative skills involve the ability to get ideas across to someone else in a clear and concise manner. It also involves such activities as listening, asking questions, sharing, writing, graphing, discussing, and reporting.  The school Science Education Program should provide students with many opportunities to communicate ideas with others.	<p><b>By the end of grade 8, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Use mathematical concepts and symbols in data analysis to support explanations and conclusions.</li> <li>Identify factors which contribute to accuracy and relevance in communication between individuals.</li> <li>Communicate the significant components of the experimental design and results of a scientific investigation.</li> </ul>
<b>Using Space-Time Relationships</b>	Skill in dealing with space-time relationships necessitates an understanding of relative position in space, mapping, relative motion, scaling and time.  The school Science Education Program should build understanding of these concepts by providing students the necessary developmental learning experiences.	<p><b>By the end of grade 8, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Draw a map of a scene to scale.</li> <li>Use cardinal (principal) directions when identifying the route between given locations on a map.</li> <li>Demonstrate an understanding of the coordinate system.</li> <li>Describe how a scene would look like if seen from a position other than one's own.</li> <li>Move an object or identify movement in a given angular or linear direction</li> </ul>
<b>Process Integration</b>	Process integration involves the ability to synthesize the skills learned to solve problems (i.e., knowledge, process skills, attitudes, and values). At the first level, it involves solving problems, which are familiar. At the more advanced level, it involves the ability to utilize skills, knowledge and attitudes and apply them to a unique or original situation to solve a problem.  The school Science Education Program should provide students with many inquiry-based problem solving	<p><b>By the end of grade 8, students should be able to:</b></p> <ul style="list-style-type: none"> <li>Identify a scientific problem to be investigated, propose or identify a testable hypothesis, and devise an appropriate experimental design to collect data to answer the question.</li> <li>Identify the process of applying generalizations to the interpretation of information as deduction (deductive logic, deductive reasoning).</li> </ul>